Bi-directional tDCS produces anterior and posterior current flow in neighbouring cortical targets

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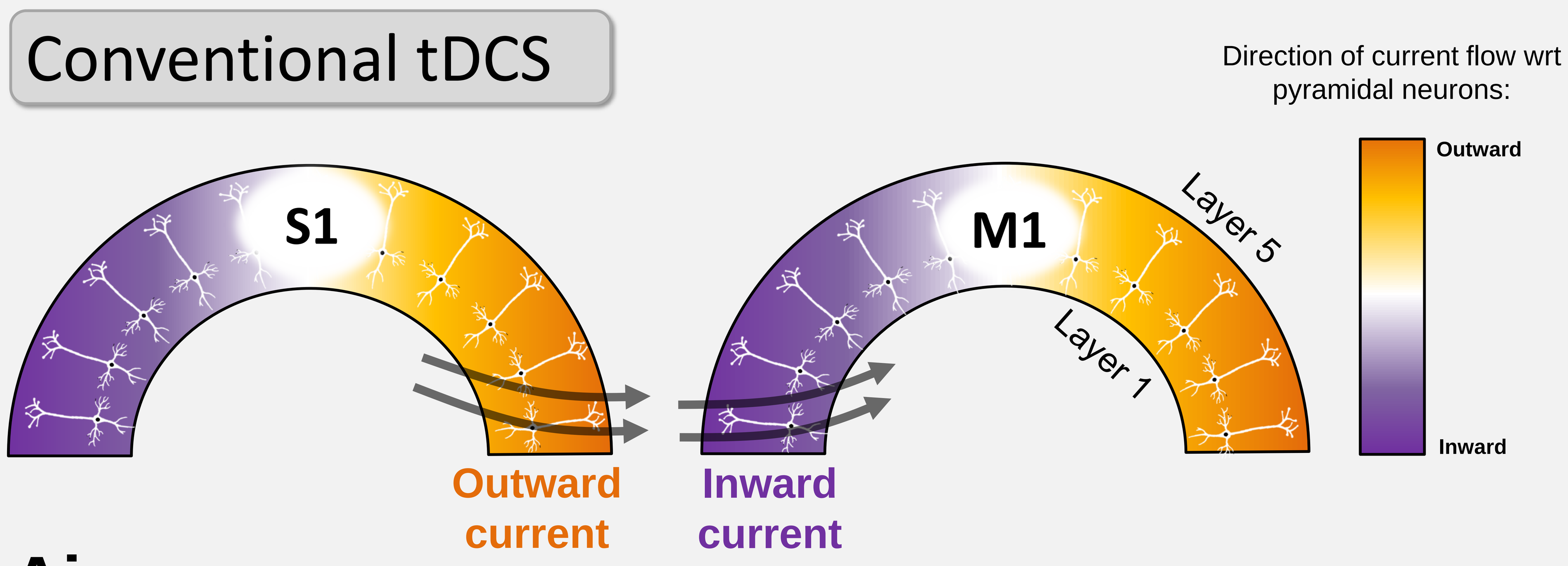
Background

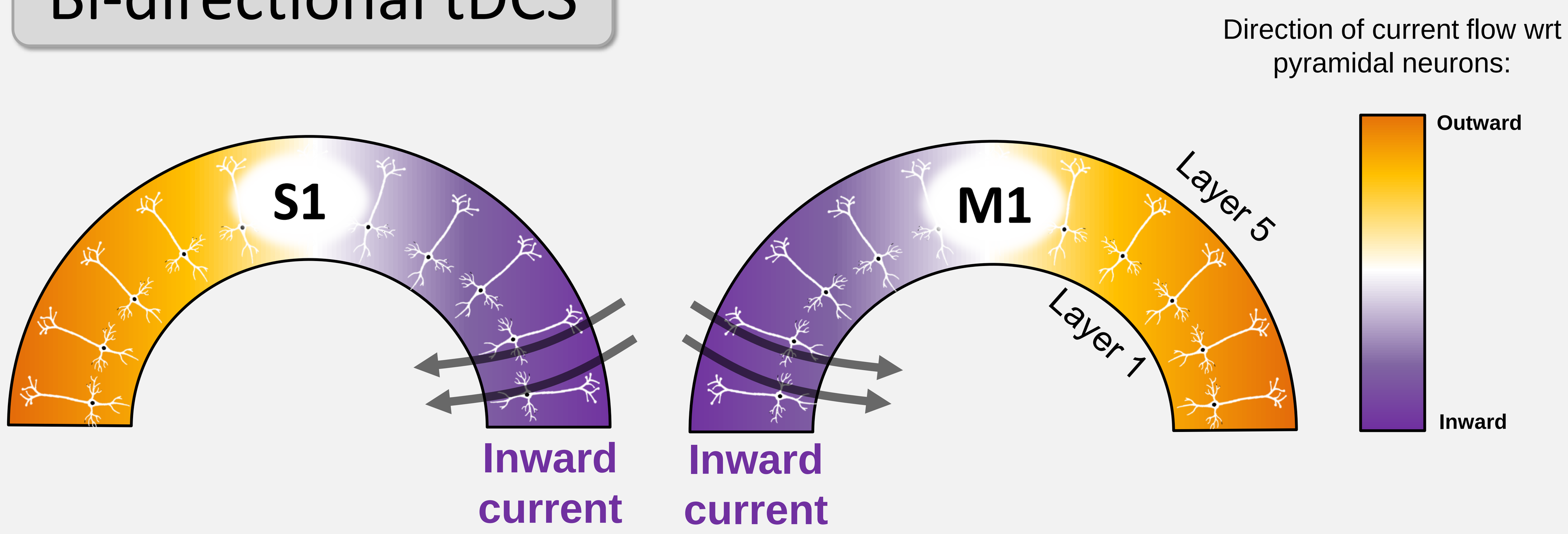
- Direction of tDCS current flow relative to cortical pyramidal neurons dictates stimulation effect[1,2].
- Inward current flow is associated with excitation, outward current flow can be inhibitory[3,4].
- Pyramidal neurons in primary motor and sensory cortices (M1 and S1) are predominantly oriented in opposite directions.
- This means opposite polarization of M1 and S1 neurons with commonly used montages.

Conventional tDCS



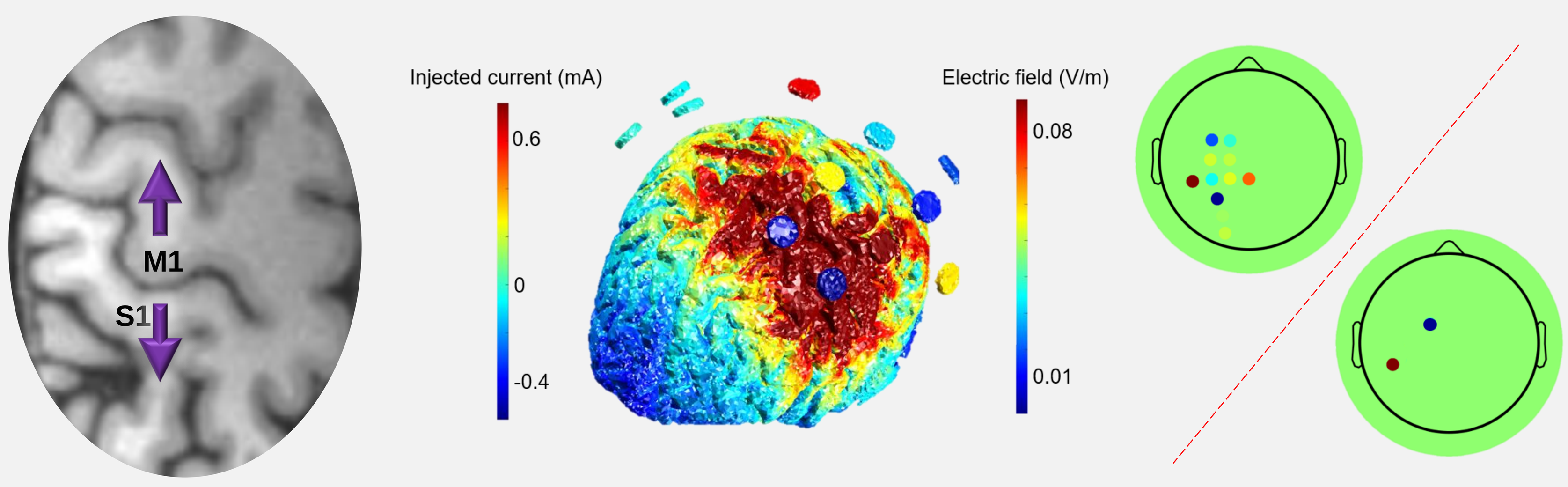
Aim:
Establish and validate custom electrode montage to produce uniform polarization (**inward**/**outward**) in S1 *and* M1.

Bi-directional tDCS



Modelling and design

- Cortical M1 and S1 coordinates in MRI scans from the Human Connectome project[5] were identified according to published guidelines[6]
- ROAST[7-10] was used to determine a montage and stimulation intensity which achieves bi-directional current flow in M1 and S1.
- Maximum stimulator output was limited to 1mA per electrode and 4mA total injected current across the head.
- This bi-directional montage was compared with a conventional montage with 1mA injected current.

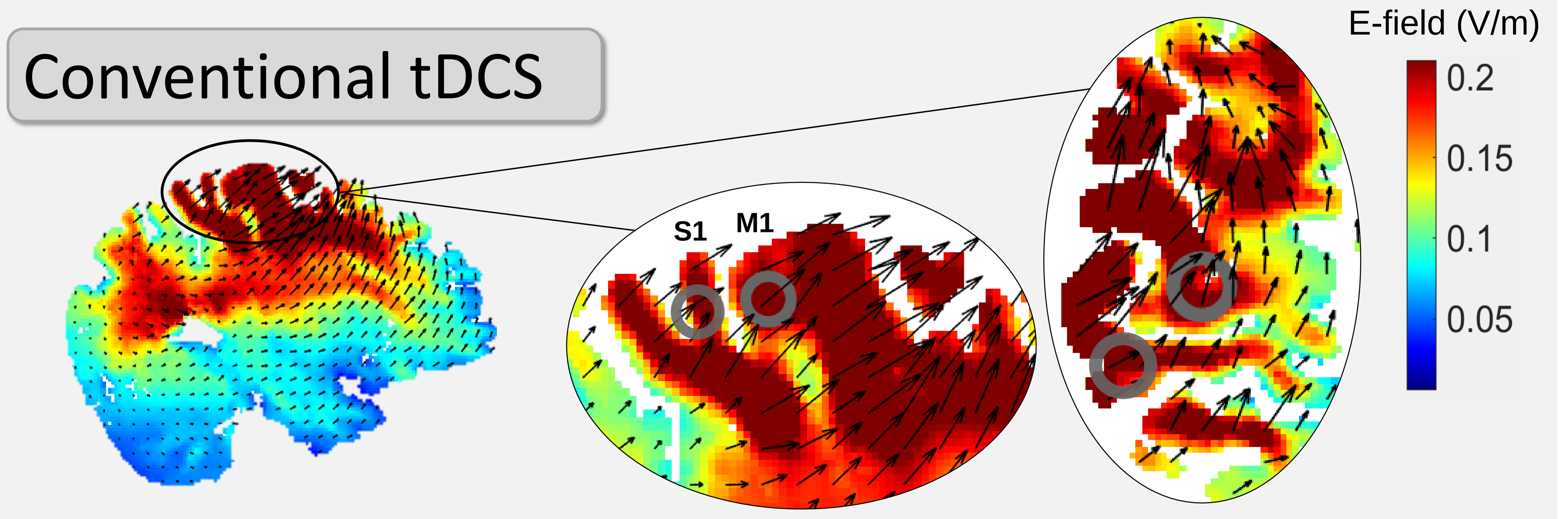


1. MRI[5]. Identify left M1 and S1 and specify E-field target direction → **2. Simulate current flow using ROAST[7-10]** → **3. Compare M1/S1 E-field direction in conventional and bi-directional montages**

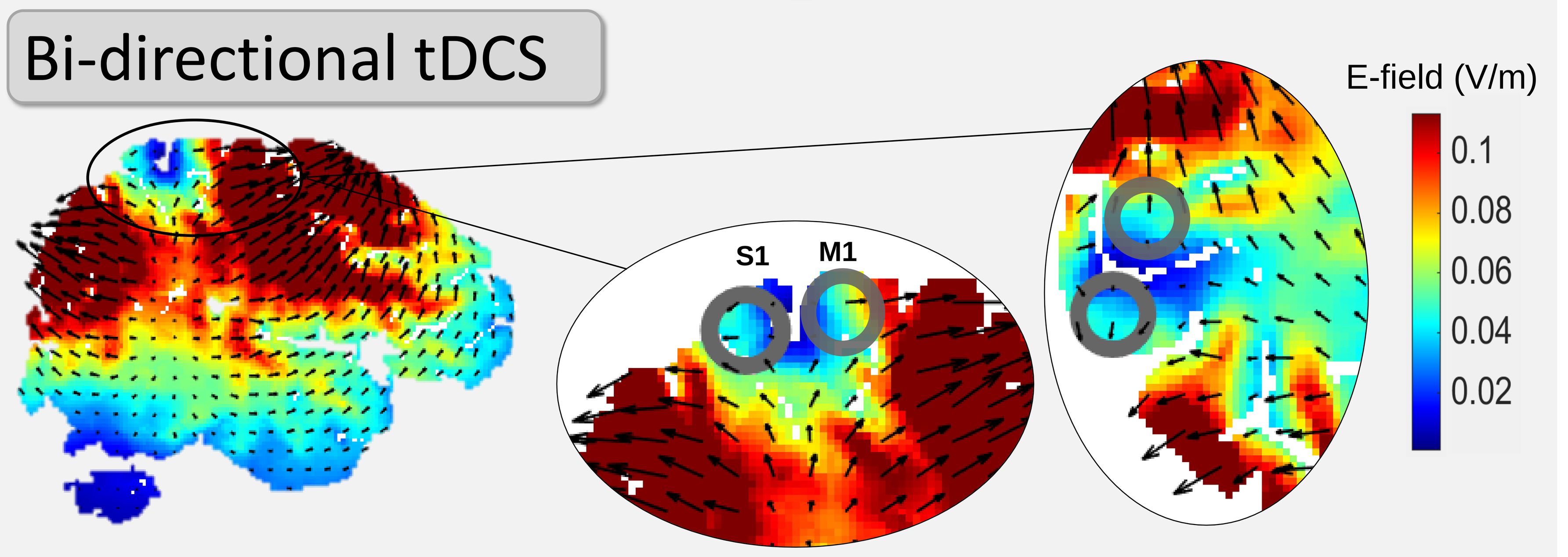
Uniform M1/S1 polarization

- Custom HD-tDCS montage can produce uniformly polarizing current simultaneously in M1 and S1.
- Bi-directional current flow is achieved at the cost of E-filed intensity at cortical targets, and a conventional montage achieves desired intensity at the cost of direction.

Conventional tDCS

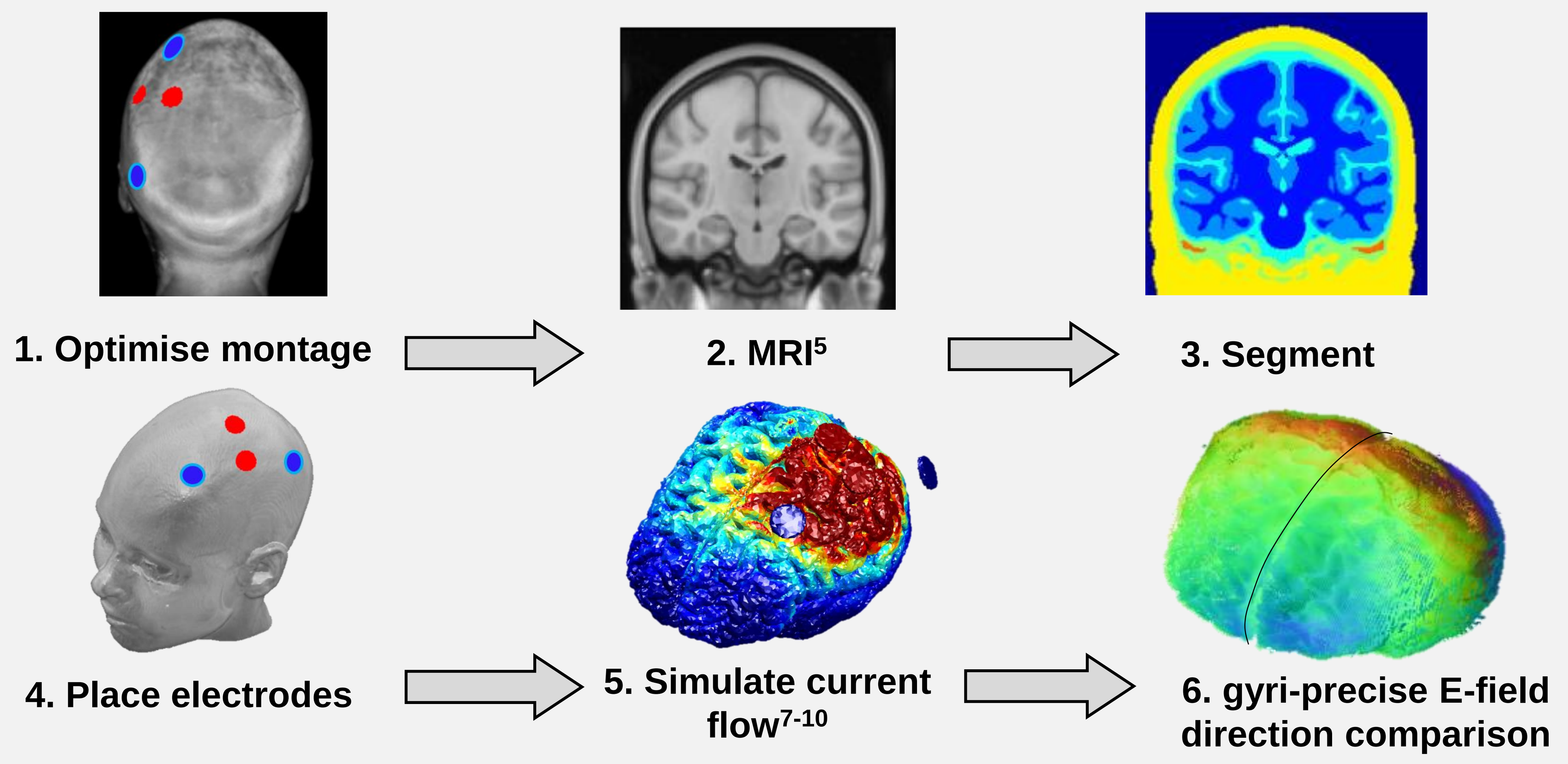


Bi-directional tDCS

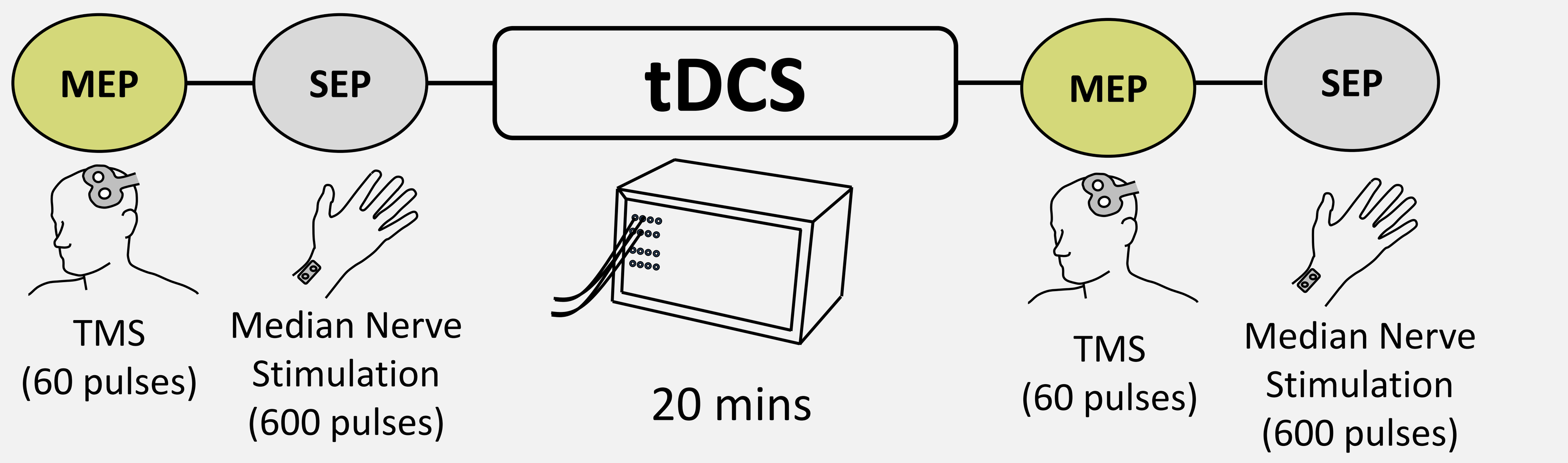


Modelling next steps

- Custom MATLAB routines define individualised electrode montage required to achieve bi-directional current flow while maintaining higher E-field intensity. 2mA injected current modelled in ROAST[7-10].
- Quantify net direction of 3D current flow through M1 and S1 and compare to surface norms for a gyri-precise model.



Physiological validation (ongoing)



Summary and Outlook

- Custom 'bi-directional' montage simultaneously produces current flow in the same direction in M1 and S1, with respect to the orientation of pyramidal neurons.
- This may lead to similar changes in M1 and S1 excitability, due to uniform (as opposed to opposite) polarization of these areas
- Physiological validation study to test this prediction is ongoing.

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